ties in cultivated soils. We might be disposed to eliminate the potash as also usually sufficiently prevalent. The fact that straw is almost invariably returned to arable land is in itself a safeguard against the exhaustion of potash; and the considerable percentage found in most soils, especially those of argillaceous character, points to the same conclusion. The farmer has then chiefly to consider the supply of phosphates and of nitrates, and, with regard to these two, Prof. Wagner thinks that the former ought to be in excess of what is required, and that the farmer should equally devote his attention to the proper supply and application of nitrates to the soil. The recommendation that phosphates should be in excess is based on the observation that growth is seldom regular. It depends on climatic conditions, and sometimes is arrested by drought or low temperature for two or three weeks, while in well cultivated and well fertilized ground vegetation makes extraordinary progress in three or four days. The supply of phosphates ought therefore to be in excess of what may be required under ordinary conditions of growth, and should be abundant enough to supply the plant under the most rapid conditions of growth. The conclusion is that phosphates may be applied liberally and without hesitation or limit, *i.e.*, without scientific accuracy. The case of nitrates is different, as they are so easily available and so freely mobile in the soil, that the plant has no difficulty in appropriating them. The nitrates probably find their way into the plant before they are required, and are stored up and elaborated gradually as the plant takes up further supplies of mineral nutriment. The rapidity with which they disappear and their extraordinary effect mark the nitrates out as the chief object of study in manuring land.

JOHN WRIGHTSON.

THE BURIAL CUSTOMS OF THE AINOS.

MR. BACHELOR, to whose investigations on the subject of the Ainos of Yezo we have frequently referred, writes, in a recent issue of the *Japan Weekly Mail*, on the burial customs of this race. He says that as soon as a person dies, a blazing fire is made, the corpse is dressed in its best garments, which are neatly laced up, and is laid lengthways on the right-hand side of the fireplace. The relatives and friends of the deceased sit around the remaining parts of the fireplace, and usually they are so numerous as to fill the hut. In all cases many sacred symbols (*inao*) are made, and placed around the hut and the dead body. Mr. Bachelor has seen the corpse of a woman laid out. She was well dressed, and had her utensils and paraphernalia about her (the rings and beads being, in this instance, laid upon her bosom), and was shod with pieces of white calico which Mrs. Bachelor had, a few days previously, given to the husband of the deceased to bind up his wounded foot. Any white material seems to be especially welcome to the Ainos for wrapping up the bodies of their dead. When the body has been properly dressed, and when the necessary eating-vessels or hunting materials are placed in position, a cake made of millet, or a cup of boiled rice and some wine, are placed by its side, and the spirit of the departed is supposed to eat up the essence of these things. Then the goddess of fire is implored to take charge of the spirit and lead it safely to the Creator of the world and the possessor of heaven, and she receives various messages to the Deity setting forth the praises of the dead and extolling his many virtues. Millet cakes and wine are then handed round to every member of the assembled company, and each of them offers two or three drops of the wine to the spirit of the dead, then drinks a little, and pours what remains before the fire as an offering to the fire-goddess, to whom they have not ceased to pray; then part of the millet cake is eaten, and the remainder buried in the ashes on the hearth, each person burying a little piece. After the burial these scraps are collected and carried out of the hut and placed before the east window, which is regarded as the sacred place. The corpse is then carefully rolled up in a mat, neatly tied up, attached to a pole, and carried to the grave by two men. The mourners follow after the corpse, in single file, each carrying something to be buried in the grave, the men leading and the women following them. The grave is from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet deep, and round the inside of it stakes are driven, and over them and at the bottom of the grave mats are placed. Then the body is laid in the grave, with numerous little knick-knacks—cups, rings, beads, a saucepan and some clothing being buried with the woman, a bow and quiver, an eating and a drinking cup, tobacco, a pipe, a knife with the men, and play-things with the children. These things are always broken before being put into the grave, and it is noticeable that they are not usually the best the deceased had during life. Everything is then closely covered with mats; pieces of wood are placed so as to form a kind of roof, and on this the earth is piled. A pole is generally stuck at the foot of the grave to mark the spot. No prayers are offered up during burial. The mourners then return to the hut, where the men pray, make *inao*, *i.e.* sacred symbols, eat, drink, and get drunk. The dead body is never allowed to remain in the house longer than one day; and, once the funeral is over, the name of the departed is never mentioned.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE following is the list of Scholarships, prizes, and Associateships awarded in July 1888, at the Normal School of Science and Royal School of Mines, South Kensington, for the session 1887–88:—

First Year's Scholarships: Samuel H. Studley, Sydney Wood, William S. Jarratt, and George N. Huntly. Second Year's Scholarships: Savannah J. Speak and William Tate.

Edward Forbes Medal and Prize of Books for Biology: Arthur M. Davies. Murchison Prize of Books for Geology: William Tate and Samuel Truscott. The Murchison Medal was not awarded. Tyndall Prize of Books for Physics: William Watson. De la Beche Medal for Mining: Edmund L. Hope. Bessemer Medal and Prize of Books for Metallurgy: Harry C. Jenkins. Frank Hatton Prize of Books for Chemistry: James W. Rodger.

Prizes of Books given by the Science and Art Department:—Mechanics, James Whitaker; Astronomical Physics, William S. Jarratt and William Watson; Practical Chemistry, James W. Rodger and James Young; Mining, John M. Beckwith. The prize for Principles of Agriculture and Agricultural Chemistry was not awarded.

Associateships (Normal School of Science):—Mechanics, 1st Class: James Whitaker and William Kelsall. Physics, 1st Class: Harry E. Hadley and Philip L. Gray; 2nd Class: Herbert Anderson and Philip L. Coultas. Chemistry, 1st Class: James W. Rodger, James Young, Barker North, and Harold E. Hey; 2nd Class: William MacDonald, George Grace, Francis J. Hardy, George C. McMurtry, and Henry Sowerbulls. Biology, 1st Class: Arthur M. Davies. Geology, 1st Class: Thomas H. Holland.

Associateships (Royal School of Mines):—Metallurgy, 1st Class: Harry C. Jenkins, Thomas Clarkson, and William McNiell; 2nd Class: Alfred Howard. Mining, 1st Class: Edmund L. Hope, John M. Beckwith, James A. Chalmers, William F. Thomas, Sydney Allingham, Charles G. Thompson, John Leechman, Frederick H. P. Creswell, Ernest Lichtenburg; 2nd Class: Ferdinand F. L. Dielyrch, Henry L. Lewis, Henry B. Budgett, William F. Hamley, and Harold Macandrew.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 26.—"On the Coagulation of the Blood." Preliminary Communication. By W. D. Halliburton, M.D., B.Sc., Assistant Professor of Physiology, University College, London. Communicated by Prof. E. A. Schäfer, F.R.S. (From the Physiological Laboratory, University College, London.)

The present research was directed to determining the nature of the ferment that produces the change of fibrinogen into fibrin.

Some preliminary experiments showed that the following proteids were present in lymph cells (obtained from lymphatic glands).

(1) A mucin-like proteid similar to that described by Miescher in pus which swells up into a jelly-like substance when mixed with solutions of sodium chloride or magnesium sulphate. This is a nucleo-albumin.

(2) Two globulins.

(3) An albumin.

The Globulins.—There is a small quantity of a globulin which enters into the condition of a heat coagulum at about 50° C. The most abundant globulin is, however, one which resembles serum globulin in its heat coagulation temperature (75° C.), and in the way in which it is precipitated by saturation with salts, or by dialyzing out the salts from its solutions.

The term serum globulin is hardly applicable to a proteid existing in lymph cells; hence it is necessary to multiply terms, and to designate this globulin by a new name, viz. *cell globulin*. It has, moreover, certain characteristic properties which will be fully dealt with later on.

The Albumin resembles serum albumin in its properties. It coagulates at 73° C. It is present in very small quantities. It may be provisionally termed *cell albumin.*

Having thus recognized the various proteids that occur in the cells of lymphatic glands, my next endeavour was to ascertain what action, if any, these exerted on the coagulation of the blood. My experiments in this direction have been mostly performed with salted plasma. The blood is received into an approximately equal volume of saturated sodium sulphate solution. By this means coagulation is prevented, and the corpuscles settle. On subsequently removing the supernatant salted plasma, and diluting it with four or five times its bulk of water, coagulation occurs after the lapse usually of several hours; but if, instead of water, a solution of fibrin ferment be used, coagulation occurs in a few minutes.

I first tried to prepare fibrin ferment from the lymphatic glands; these were freed from blood, chopped small, and placed under absolute alcohol for some months; they were then dried over sulphuric acid, powdered, and the dry powder extracted with water. The water was found to contain the fibrin ferment. It hastened very considerably the coagulation of salted plasma. This activity was destroyed at a temperature between 74° C. and 80° C. The watery extract gave, moreover, the xanthoproteic reaction; it contained also some sodium chloride and phosphates which it had dissolved out of the dried glands.

A watery or saline extract of fresh glands also had very considerable clotting powers; that is to say, the addition of a few drops of such an extract caused diluted salted plasma to clot in a few minutes, which otherwise did not clot until after the lapse of 12–24 hours. The activity of this extract was not altered by heating to 70°; it was therefore independent of the nucleo-albumin which is disintegrated at about 50° C., or of the globulin which coagulates at that temperature. Its activity was destroyed, however, if heated above 75° C. These facts show that the extracts of both dried and fresh glands contain a substance which has the same properties as fibrin ferment, and which, moreover, is rendered inactive at the temperature at which fibrin ferment, as ordinarily prepared from serum, loses its activity.

The next question which I investigated was whether the ferment action was dependent upon, or independent of, the presence of the proteids of the cells. An extract of the cells was made with sodium sulphate solution, and saturated with ammonium sulphate; the precipitate of the proteids so produced was filtered off; the proteid-free filtrate dialyzed till free from excess of salt, and it was then found to have no power of hastening coagulation. The precipitate which contained all the proteids was washed by saturated solution of ammonium sulphate, and redissolved by adding distilled water; this solution hastened the coagulation of salted plasma very considerably. This experiment showed either that the ferment was identical with or precipitated with the proteids in the extract. It was, moreover, destroyed at a temperature at which these proteids were coagulated, viz. about 75° C.; there are, however, in the solution two proteids which are coagulated at about this temperature, viz. the cell globulin and the cell albumin. The globulin and the albumin were then separated from one another, and it was found that the globulin and not the albumin had the properties of fibrin ferment.

After I had performed the experiments just related, the question naturally arose, Is this cell globulin the same thing as what has been termed fibrin ferment when prepared from serum? From the experiments which were performed in order to elucidate this question the following conclusions were drawn:—

(1) Lymph cells yield as one of their disintegration products a globulin which may be called cell globulin. This has the properties that have hitherto been ascribed to fibrin ferment.

(2) Fibrin ferment as extracted from the dried alcoholic precipitate of blood serum is found on concentration to be a globulin with the properties of cell globulin.

(3) The fibrin ferment as extracted by saline solutions from "washed blood clot" is a globulin which is also identical with cell globulin.

(4) Serum globulin as prepared from hydrocele fluid has no fibrinoplastic properties. It may perhaps be better termed plasma globulin.

(5) Serum globulin as prepared from serum has marked fibrinoplastic properties. This is because it consists of plasma globulin, and cell globulin derived from the disintegration of white blood corpuscles, which are in origin lymph cells.

(6) The cause of coagulation of the blood is primarily the disintegration of the white blood corpuscles; they liberate cell globulin, which acts as a ferment converting fibrinogen into fibrin. It does not apparently become a constituent part of the fibrin formed.

This confirmation and amplification of Hammarsten's views concerning the cause of the coagulation of the blood is in direct opposition to the theories of Wooldridge, which may be stated as follows:—The coagulation of the blood is a phenomenon essentially similar to crystallization; in the plasma there are three constituents concerned in coagulation, A, B, and C fibrinogen. A and B fibrinogen are compounds of lecithin and proteid, and fibrin results from the transference of the lecithin from A fibrinogen to B fibrinogen. C fibrinogen is what has hitherto been called fibrinogen; A fibrinogen is a substance which may be precipitated by cooling "peptone plasma," and on the removal of this substance coagulation occurs with great difficulty. The precipitate produced by cold consists of rounded bodies resembling the blood-plates in appearance. He further found that other compounds of lecithin and proteid, to which he has extended the name of fibrinogen, exist in the thymus and other organs, in the fluid of lymph glands, and in the stromata of red corpuscles; these substances may be extracted from the organs by water, and precipitated from the aqueous extract by acetic acid, and on redissolving this in a saline solution, and injecting it into the circulation of a living animal, intravascular clotting occurs which results in the death of the animal. This form of fibrinogen (?) that acts thus he looks upon as the precursor of A fibrinogen. From these points of view the fibrin ferment and the white corpuscles are looked upon as of secondary import in causing coagulation, though it is admitted that fibrin ferment converts C fibrinogen into fibrin.

The Influence of Lecithin in the Coagulation of the Blood.—Lecithin hastens the coagulation of blood-plasma, which has been prevented from clotting by the injection into the circulation of a certain quantity of commercial peptone; but peptone plasma, as I shall show more fully in the next section, differs so much from normal plasma, that it is impossible to draw correct conclusions from experiments performed with it, unless they be supported by confirmatory evidence on solutions of fibrinogen and pure plasma, such as one obtains from a vein, or from the pericardial sac, and lecithin does not cause coagulation in such cases.

The supposition that "fibrinogen A" acts by giving up its lecithin to "fibrinogen B" to form fibrin, seems, therefore, to be a pure assumption, and is unsupported by analytical evidence. Cell globulin contains no phosphorus, and can therefore contain no lecithin.

The Precipitate produced by cooling Peptone Plasma.—The chief point I wish to urge is that this precipitate is obtained on cooling peptone plasma only, and from no other form of plasma. I have repeatedly attempted to obtain such a precipitate by cooling to 0° C. pure plasma from the veins of the horse, salted plasma, hydrocele fluid, and pericardial fluid, but in all cases with a negative result. It therefore occurs in peptone plasma alone; and that it is due to the peptone is supported by the fact that if one takes an aqueous solution of "Witte's peptone" and cools it to 0° C., a precipitate is formed consisting of rounded granules very similar to blood-tablets. This precipitate moreover consists of hetero-albumose. (Witte's peptone contains a large admixture of albumose.) That peptone blood does differ in one other important particular from normal blood, viz. in the heat coagulation temperatures of its proteids, was shown by Wooldridge himself. It is on these grounds, then, that I hold we cannot regard peptone plasma as being at all comparable to normal plasma.

Intravascular Coagulation.—No doubt the crude and impure substance introduced into the veins produces intravascular clotting; but I must protest against the extension of the name fibrinogen to such substances. It seems to me it would be just as correct to call a piece of iron wire introduced into the sac of an aneurysm to produce coagulation there, a fibrinogen.

With regard, however, to these tissue-fibrinogens of Wooldridge, I think we may venture to offer a suggestion as to their real nature, or, at any rate, as to the nature of one of their constituents. From the last paper published by Wooldridge, we find that they are imperfectly soluble in water, readily precipitated by acids, and soluble in excess of those reagents; that they yield on gastric digestion a substance which is insoluble and which is rich in phosphorus. From these details of their properties, I think we may draw the conclusion, not that they contain lecithin, as Wooldridge affirms, but that they belong to the group of proteids described in the former part of this paper under Hammarsten's name of nucleo-albumin. Nucleo-albumins yield when poured into water a stringy precipitate resembling mucin, and in a former paper Wooldridge speaks of the precipitate of his tissue fibrinogen (precipitated by acetic acid) as being a bulky one. If my conjecture is correct, it would be exceedingly likely that when a saline solution of such a substance was injected into the circulation, it would form strings of a slimy mucinoid description in the vessels, and that these would form the starting-point for the thrombosis or intravascular coagulation that ensues.

May 3.—"On the Induction of Electric Currents in Conducting Shells of Small Thickness." By S. H. Burbury.

(1) *Definition and Explanation of the Notation employed.*—A *current-sheet* in any field of electric currents is a surface to which the stream-lines are everywhere tangential. A *current*-shell is the space between two current-sheets very near each other. The *superficial current* in a current-shell is the quantity of electricity which in unit time crosses unit length of a line drawn on either sheet perpendicular to the current. If U, V, W be the components of superficial current, there always exists a function, ϕ, called *the current function*, such that—

$$U = n\frac{d\phi}{dy} - m\frac{d\phi}{dz}, \text{ \&c.},$$

l, m, n being the direction cosines of the normal. This function completely determines the superficial currents.

The corresponding expressions for the component currents per unit of area are—

$$u = \frac{dS}{dz}\frac{d\Phi}{dy} - \frac{dS}{dy}\frac{d\Phi}{dz}, \text{ \&c.},$$

where S and Φ are any two functions of x, y, and z.

The components of *vector potential* due to a current-sheet are—

$$F = \iint \frac{U}{r} dS = \iint \frac{1}{r}\left(n\frac{d\phi}{dy} - m\frac{d\phi}{dz}\right) dS.$$

And if the sheet be closed, this may be put in the form—

$$F = \iint \phi\left(m\frac{d}{dz} - n\frac{d}{dy}\right)\frac{1}{r} dS\,;\ G = \text{\&c.}$$

So that F, G, and H are linear functions of the ϕ's with coefficient functions of the co-ordinates.

If the current-sheet be spherical, the vector potential is tangential to any concentric spherical surface.

The *electro-kinetic energy* of a system of current-sheets is—

$$2T = \iiint (FU + GV + HW) dS$$

over all the sheets; that is—

$$\iiint \left(\phi\left(m\frac{dF}{dz} - n\frac{dF}{dy}\right) \text{\&c.}\right) dS,$$

if the surfaces be closed; and if Ω be the magnetic potential, this reduces to—

$$-\iint \phi\frac{d\Omega}{d\nu} dS,$$

$\frac{d\Omega}{d\nu}$ denoting the space variation of Ω per unit length of the normal measured outwards. Also, $\frac{d\Omega}{d\nu}$ is shown not to be discontinuous in passing through a sheet of superficial currents. T is expressible as a quadratic function of the ϕ's with coefficients functions of the co-ordinates.

(2) *Comparison with Magnetic Shells.*—The components of vector potential due to a magnetic shell placed on a closed surface, S, with variable strength, ϕ (reckoned as positive when the positive face is outwards), are—

$$F = \iint \phi\left(m\frac{d}{dz} - n\frac{d}{dy}\right)\frac{1}{r} dS.$$

They are, then, the same as those due to a system of currents on S determined by ϕ as current function. Hence the magnetic induction due to the magnetic shell is the same as that due to the corresponding system of currents at any point in free space.

(3) If Ω_0 denote the magnetic potential due to any magnetic system outside of S, it is possible to determine ϕ so that a shell of strength ϕ on S has, at all points on or within S, potential equal and opposite to Ω_0. General determination of ϕ to satisfy this condition. The solution is unique.

(4) Therefore, also, there exists a system of currents on S, having ϕ for current function, such that the magnetic force due to it is equal and opposite to that due to the external system at all points on or within S. This system is called the *magnetic screen* on S to the external system. Example of a sphere.

(5) *General Solution of the Problem of Induction, Resistance not being yet taken into account.*—If S_0, Ω_0, ϕ_0, &c., relate to a magnetic system outside of S, Ω and ϕ to S and superficial currents upon it, the whole electro-kinetic energy is—

$$\iint \phi_0\left(\frac{d\Omega_0}{d\nu} + \frac{d\Omega}{d\nu}\right) dS_0$$
$$+\iint \phi\left(\frac{d\Omega_0}{d\nu} + d\Omega\right) dS.$$

In this form, T has as many variables—namely, the values of ϕ—as it has degrees of freedom.

If, therefore, the external system be continuously varied, the induced current on S will be given by

$$\frac{d}{dt}\frac{dT}{d\phi} = 0 \text{ on S},$$

that is,

$$\frac{d}{dt}\left(\frac{d\Omega_0}{d\nu} + \frac{d\Omega}{d\nu}\right) = 0 \text{ on S},$$

that is,

$$\frac{d}{d\nu}\left(\frac{d\Omega_0}{dt} + \frac{d\Omega}{dt}\right) = 0 \text{ on S}.$$

And since $\nabla^2\frac{d\Omega_0}{dt} = 0$, and $\nabla^2\frac{d\Omega}{dt} = 0$ at all points within S it follows that $\frac{d\Omega_0}{dt} + \frac{d\Omega}{dt} = 0$ at all points within S.

That is, the induced currents, on their creation, are the *magnetic screen* to the time variation of the external field. This gives the law of formation of the currents, however rapidly they may decay by resistance.

(6) *Of a Solid Conductor.*—If S be a hollow shell, there will, as the direct result of induction, be zero magnetic force at all points within it. Therefore, if it be filled with conducting matter so as to form a solid conductor, none but superficial currents will, as the direct consequence of the variation of the external field, be induced in it. But as the superficial currents decay by resistance, their variation induces currents in the inner strata of the solid, so that in time, and no doubt generally in a very short time, the solid becomes pervaded by currents. The currents penetrate the solid, and the initial *rate of penetration* can be calculated under certain conditions (see *post*, 15).

(7) *Of the Associated Function.*—If F, G, H be the components of any vector which satisfy

$$\frac{dF}{dx} + \frac{dG}{dy} + \frac{dH}{dz} = 0$$

at all points within a closed surface, S, there exists a function, χ, called the *associated function*, such that—

$$\frac{d\chi}{d\nu} = lF + mG + nH \text{ on S},$$
$$\nabla^2\chi = 0 \text{ within S}.$$

The components F, G, H of vector potential of a system of closed currents outside of S have an associated function, χ, on S.

In like manner $-\frac{dF}{dt}$, $-\frac{dG}{dt}$, and $-\frac{dH}{dt}$ have an associated function, which shall be denoted by ψ.

(8) If $\frac{dF}{dt}$, $\frac{dG}{dt}$, and $\frac{dH}{dt}$ relate to an external system and its magnetic screen on S, we have

$$\frac{d}{dt}\frac{dF}{dy} = \frac{d}{dt}\frac{dG}{dx}, \text{ \&c., within S,}$$

whence it follows that

$$-\frac{dF}{dt} = \frac{d\psi}{dx}, \; -\frac{dG}{dt} = \frac{d\psi}{dy}, \text{ \&c.}$$

If, therefore,

$$-\frac{dF}{dt}, \; -\frac{dG}{dt}, \; -\frac{dH}{dt}$$

are the components of an *electromotive force* within S, there will form on S a distribution of statical electricity having potential ψ, and forming a complete *electric screen* to the external system.

(9) *Of Self inductive Systems of Currents on a Surface.*—If any system of currents in a conducting shell be left to decay by resistance, uninfluenced by any external induction, it may be the case that they decay proportionally; so that, if U_0, V_0, W_0 denote the initial values of the component currents, their values at time t are $U = U_0\epsilon^{-\lambda t}$, $V = V_0\epsilon^{-\lambda t}$, $W = W_0\epsilon^{-\lambda t}$, and $\frac{dU}{dt} = -\lambda U$, &c., where λ is a constant proportional to the specific resistance, and inversely proportional to the absolute thickness. If this be the case, the system is defined to be *self-inductive.*

(10) By Ohm's law we have, whether the system be self-inductive or not,—

$$\sigma u = -\frac{dF}{dt} - \frac{d\psi}{dx}, \text{ \&c.,}$$

where u is the component current per unit of area, and σ the specific resistance.

If h be the thickness of the shell, $\sigma u = \frac{\sigma}{h}U$, and the equations may be written—

$$\frac{\sigma}{h} = \frac{-\frac{dF}{dt} - \frac{d\psi}{dx}}{U} = \frac{-\frac{dG}{dt} - \frac{d\psi}{dy}}{V}, \text{ \&c.}$$

If the system be self-inductive $-\frac{dF}{dt} = \lambda F$, &c., and $-\frac{d\psi}{dx} = \lambda\chi$, where χ is the associated function to F, G, and H, and ψ to $-\frac{dF}{dt}$, $-\frac{dG}{dt}$, and $-\frac{dH}{dt}$. Therefore—

$$\frac{\sigma}{h} = \lambda\frac{F + \frac{d\chi}{dz}}{U} = \lambda\frac{G + \frac{d\chi}{dy}}{V} = \lambda\frac{H + \frac{d\chi}{dz}}{W}.$$

(11) Now if we assume as current function on S any arbitrary function, ϕ, we thereby determine U, V, W, and therefore also F, G, H, and χ, at all points on S. It will not be generally true that—

$$\frac{F + \frac{d\chi}{dx}}{U} = \frac{G + \frac{d\chi}{dy}}{U} = \frac{H + \frac{d\chi}{dz}}{W}.$$

These equations constitute a condition which the current function ϕ must satisfy in order that the system may be capable of being made self-inductive. Their geometrical interpretation is that the tangential component of vector potential of the currents in the sheet coincide with the current at every point.

If ϕ be chosen to satisfy that condition, then by the equation—

$$\frac{\sigma}{h} = \lambda\frac{F + \frac{d\chi}{dx}}{U} = \lambda Q \text{ (suppose)}$$

we determine h, the thickness of the shell at every point, necessary to make the shell self-inductive, *i.e.* $h = \frac{\sigma}{\lambda Q}$.

(12) *Examples of Self-inductive Systems.*—1. S a sphere, and ϕ any spherical surface harmonic of one order. Here h is a constant.

2. S a surface of revolution about the axis of z, and ϕ a function of z only.

3. Any surface, with ϕ a function of z only, if χ is independent of z. Example: an ellipsoid whose axes are the axes of co-ordinates, and $\phi = Az$. It is found in this case that $\psi \propto xy$, and therefore the necessary condition for a self-inductive system is satisfied; and also, to make it self-inductive, h varies as the perpendicular from the centre on the tangent plane at the point.

(13) *Co-existence of Self-inductive Systems.*—If any number of self-inductive systems be created in the same shell, each decays according to its own law, unaffected by the others. If all have the same value of λ, then, as the effect of resistance apart from induction, we have

$$\frac{d\Omega}{dt} + \lambda\Omega = 0,$$

where Ω is the magnetic potential of the whole system.

(14) *General Property of Self-inductive Systems.*—If an external system so vary as that the system of currents in the shell S, induced at any instant, shall always be self-inductive, and with the same value of λ, we have, to determine the currents in the shell at any instant, the equation—

$$\frac{d\Omega_0}{dt} + \frac{d\Omega}{dt} + \lambda\Omega = 0,$$

from which Ω can be found, if $\frac{d\Omega_0}{dt}$ is given.

Example 1.—Let $\frac{d\Omega_0}{dt} = C$, a constant. In this case we find $\Omega = \frac{C}{\lambda}\left(1 - \epsilon^{-\lambda t}\right)$ If C be very great, and t very small, this approximates to the ideal case of an impulsive force, and Ω becomes equal to Ct, and is independent of the resistance. If, on the other hand, λt be very great, we have $\Omega = \frac{C}{\lambda}$, and Ω varies inversely as the resistance.

Example 2.—Let $\Omega_0 = A\cos kt$, where k is constant, and A independent of the time, but a function of position. This leads to the result—

$$\Omega = -A\sin\alpha\sin\overline{kt-\alpha},$$

$$\Omega_0 + \Omega = A\cos\alpha\cos\overline{kt-\alpha},$$

at all internal points. Here, α is *the retardation of phase*, and is equal to $\cot^{-1}\frac{\sigma}{Qhk}$.

For instance, if S is a sphere of radius a, and $\phi = A\cos kt$, $Q = \frac{2n+1}{4\pi a}$, and the result obtained agrees with that given by Prof. Larmor in *Phil. Mag.*, January 1884.

(15) If the shell be infinitely thin—

$$\alpha = \sin\alpha = \frac{Qhk}{\sigma},$$

the same phase is reached in the inner field at a time later by $\frac{\alpha}{k}$, that is, $\frac{Qh}{\sigma}$, than in the outer field. The ratio which in the limit h bears to this difference of time is $\frac{\sigma}{Q}$, and is, in case of a solid conductor, the initial *velocity* with which the currents penetrate the solid.

(16) If S be any homogeneous function of positive degree in x, y, and z, the space within $S = 0$ may be conceived as divided into a number of concentric similar and similarly situated shells, each between two surfaces of the type $S = c$ and $S = c + dc$. Let ϕ be a function, which, as current function, gives a self-inductive system of currents in each shell of the series, if made a conductor. Let an outer shell of the series be described on S, and an inner shell of the series on S′. Let currents of the type ϕ be generated in the shell S. Let u, v, w be the functions—

$$u = \frac{dS}{dz}\frac{d\phi}{dy} - \frac{dS}{dy}\frac{d\phi}{dz}, \text{ \&c.}$$

Then u, v, w may be the components per unit of area of a system of currents in the shell S. And since this system is self-inductive,—

$$\sigma u = \lambda\left(F + \frac{d\chi}{dx}\right) \text{ on S.}$$

Now $\nabla^2 F = 0$, and $\nabla^2\chi = 0$ at all points within S.

If, therefore, $\nabla^2 u = 0$ at all points within S,

$$\sigma u = \lambda\left(F + \frac{d\chi}{dx}\right) \text{ at all points within S.}$$

That is,

$$\sigma u = -\frac{dF}{dt} - \frac{d\psi}{dx}, \text{ \&c., on } S'.$$

Therefore the creation of the given system of currents on S acts as an electromotive force tending to produce the currents u, v, w with reversed signs on S′. And since this system of currents in S′ is self-inductive, it will be actually generated by induction. As an example, if

$$S = \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2}$$

and $\phi = Az$,

$$u = \frac{dS}{dz}\frac{d\phi}{dy} - \frac{dS}{dy}\frac{d\phi}{dz} = -2A\frac{y}{b^2};$$

and therefore $\nabla^2 u = 0$.

It follows that the creation in an ellipsoidal shell of thickness proportional to the perpendicular from the centre on the tangent plane of a system of currents of the type $\phi = Az$ generates by induction the corresponding system of currents with reversed sign in an inner concentric similar and similarly situated ellipsoidal shell.

(17) *Case of an Infinite Plane: Arago's Disk.*—In this case, if the shell be of uniform thickness, a system of currents in it will not be generally self-inductive, but admits, nevertheless, of mathematical treatment. Suppose the plane to be fixed, and the field to revolve round an axis perpendicular to it, taken for that of z, with uniform angular velocity, ω.

Let y be the normal force due to the field, y' that due to the induced currents. Then we have, as the effect of induction,—

$$\frac{dy}{dt} + \frac{dy'}{dt} = 0.$$

As the effect of resistance—

$$\frac{dy'}{dt} = \frac{\sigma}{2\pi}\frac{dy'}{dz};$$

and, therefore, for the whole variation of y'—

$$\frac{dy}{dt} + \frac{dy'}{dt} = \frac{\sigma}{2\pi}\frac{dy'}{dz}.$$

When the motion is steady—

$$\frac{dy}{dt} = \omega\frac{dy}{d\theta}, \quad \frac{dy'}{dt} = \omega\frac{dy'}{d\theta},$$

θ being the angle through which the field has turned. Hence—

$$\omega\left(\frac{dy}{d\theta} + \frac{dy'}{d\theta}\right) = \frac{\sigma}{2\pi}\frac{dy'}{dz},$$

a result which agrees with Maxwell's (23) of Art. 699.

June 21.—"Effects of Different Positive Metals, &c., upon the Changes of Potential of Voltaic Couples." By Dr. G. Gore, F.R.S.

In this research numerous measurements were made, and are given in a series of tables, of the effects upon the minimum-point of change of potential of a voltaic couple in distilled water (Roy. Soc. Proc., June 14, 1888), and upon the changes of electro-motive force attending variation of strength of its exciting liquid (*ibid.*), obtained by varying the kind of positive and of negative metal of the couple, and by employing different galvanometers. The measurements were made by the method of balance through a galvanometer, with the aid of a suitable thermo-electric pile (Birm. Phil. Soc. Proc., vol. iv. p. 130; *The Electrician*, 1884, vol. xi. p. 414). The kinds of galvanometer employed were, an ordinary astatic one of 100 ohms resistance, and a Thomson's reflecting one of 3040 ohms resistance.

The following were the proportions of hydrochloric acid (HCl), required to change the potential of different voltaic couples in water :—

TABLE I.—*Hydrochloric Acid.*

Astatic Galvanometer.

Zn + Pt	between	1 in	9,300,000	and	9,388,185
Cd + Pt	,,	1 ,,	574,000	,,	637,000
Mg + Pt	,,	1 ,,	516,666	,,	574,000
Al + Pt	,,	1 ,,	12,109	,,	15,000

Reflecting Galvanometer.

Zn + Pt	between	1 in	15,000,000	and	23,250,000
Cd + Pt	,,	1 ,,	1,162,500	,,	1,550,000
Mg + Pt	,,	1 ,,	775,000	,,	930,000
Al + Pt	,,	1 ,,	42,568	,,	46,500

With iodine and the astatic galvanometer the following proportions were required :—

TABLE II.—*Iodine.*

Zn + Pt	between	1 in	3,100,000	and	3,521,970
Mg + Pt	,,	1 ,,	577,711	,,	643,153
Cd + Pt	,,	1 ,,	2[illegible]0,431	,,	224,637

With bromine and the astatic galvanometer :—

TABLE III.—*Bromine.*

Mg + Pt	between	1 in	310,000,000	and	344,444,444
Zn + Pt	,,	1 ,,	77,500,000	,,	84,545,000
Cd + Pt	,,	1 ,,	3,470,112	,,	3,875,000

The magnitudes of the minimum proportions of bromine required to change the potentials of the three couples in water varied directly as the atomic weights of the three positive metals.

With chlorine the following were the minimum proportions required :—

TABLE IV.—*Chlorine.*

With the Reflecting Galvanometer.

Mg + Pt	between	1 in	27,062,000,000	and	32,291,000,000

With the Astatic Galvanometer.

Mg + Pt	between	1 in	17,000,000,000	and	17,612,000,000
Zn + Pt	,,	1 ,,	1,264,000,000	,,	1,300,000,000
Zn + Au	,,	1 ,,	518,587,360	,,	550,513,022
Cd + Pt	,,	1 ,,	8,733,585	,,	9,270,833
Zn + Cd	,,	1 ,,	55,436	,,	76,467

In the case of chlorine, as well as that of bromine, the magnitudes of the minimum proportions of substance required to change the potential of magnesium-platinum, zinc-platinum, and cadmium-platinum, varied directly as the atomic weights of the positive metals.

The examples contained in the paper show that the proportion of the same exciting liquid necessary to disturb the potential of a voltaic couple in water varied with each different positive or negative metal, and that the more positive or more easily corroded the positive metal, or the more negative and less easily corroded the negative one, the smaller usually was the minimum proportion of dissolved substance necessary to change the potential.

By plotting the results in all cases, it was found that the order of change of potential, caused by uniform change of strength of liquid, varied with each positive metal.

The results also show that the degree of sensitiveness of the arrangement for detecting the minimum-point of change of potential depends largely upon the kind of galvanometer employed.

As a more sensitive galvanometer enables us to detect a change of potential caused by a much smaller proportion of material, and as the proportion of substance capable of detection is smaller the greater the free chemical energy of each of the uniting bodies (Roy. Soc. Proc., June 14, 1888) it is probable that the electromotive force really begins to change with the very smallest addition of the substance, and might be detected if our means of detection were sufficiently sensitive, or the free chemical energy of the uniting bodies was sufficiently strong.

"The Voltaic Balance." By Dr. G. Gore, F.R.S.

A New and Simple Lecture Experiment.—Take two small clean glass cups containing distilled water ; simultaneously immerse in each a small voltaic couple, composed of either unamalgamated magnesium or zinc with platinum, taking care that the two pieces of each metal are cut from the same piece and are perfectly clean and alike. Oppose the currents of the two couples to each other through a sufficiently sensitive galvanometer, so that they balance each other and the needle does not move. Now dip the end of a slender glass rod into a very weak aqueous solution of chlorine, bromine, iodine, or hydrochloric acid, and then into the water of one of the cups. The voltaic balance is at once upset, as indicated by the measurement of the needle, and may be shown to a large audience by means of the usual contrivances.

The chief circumstance to be noticed is the extremely great degree of sensitiveness of the arrangement in certain cases. This is shown by the following instances of the minimum proportions of substance required to upset the balance with an ordinary astatic galvanometer, and with a Thomson's reflecting one of 3040 ohms resistance.

1. *Zinc and Platinum with Iodine.* — With the astatic galvanometer, between 1 part of iodine in 3,100,000 and 3,521,970 parts of water.

2. *Zinc and Platinum with Hydrochloric Acid.*—With the astatic galvanometer, between 1 in 9,300,000 and 9,388,185 parts; and with the reflecting one, between 1 in 15,500,000 and 23,250,000 parts.

3. *Magnesium and Platinum with Bromine.*—With the astatic galvanometer, between 1 in 310,000,000 and 344,444,444 parts.

4. *Zinc and Platinum with Chlorine.*—With the astatic galvanometer, between 1 in 1,264,000,000 and 1,300,000,000 parts.

5. *Magnesium and Platinum with Chlorine.*—With the astatic galvanometer, between 1 in 17,000,000,000 and 17,612,000,000 parts; and with the reflecting one, between 1 in 27,062,000,000 and 32,291,000,000 parts of water.

Every different soluble substance requires a different proportion, and with unlike substances the difference of proportion is extremely great. With solutions of neutral salts, the proportion of substance required to upset the balance is large; for instance, with chlorate of potash, a zinc-platinum couple, and the astatic galvanometer, it lay between 1 part in 221 and 258 parts of water.

The degree of sensitiveness of the balance is usually greater, the greater the degree of chemical affinity the dissolved substance has for the positive metal and the less it has for the negative one.

By first bringing the balance with a magnesium-platinum couple and the astatic galvanometer nearly to the upsetting-point by adding 1 part of chlorine to 17,612,000,000 parts of water, and then increasing the proportion to 1 in 17,000,000,000, the influence of the difference, or of 1 part in 500,000,000,000, was distinctly detected.

"Magnetic Qualities of Nickel." (Supplementary Paper.) By J. A. Ewing, F.R.S., Professor of Engineering in University College, Dundee.

The paper is a supplement to one with the same title by Prof. Ewing and Mr. G. C. Cowan, which was read at a recent meeting of the Society. It describes experiments, conducted under the author's direction by two of his students, Mr. W. Low and Mr. D. Low, on the effects of longitudinal compression on the magnetic permeability and retentiveness of nickel. The results are exhibited by means of curves, showing the relation which was determined between the intensity of magnetisation of the metal and the magnetising force, when a nickel bar, reduced to approximate endlessness by a massive iron yoke which formed a magnetic connexion between its ends, was magnetised under more or less stress of longitudinal compression. Corresponding curves show the relation of residual magnetism to magnetising force, for various amounts of stress; and others are drawn to show the relation of magnetic permeability to magnetic induction. Initial values of the permeability, under very feeble magnetising forces, were also determined. The experiments were concluded by an examination of the behaviour of nickel in magnetic fields of great strength. Magnetising forces ranging from 3000 to 13,000 C.G.S. units were applied by placing a short bobbin with a narrow neck made of nickel between the poles of a large electromagnet, and it was found that these produced a practical constant intensity of magnetisation which is to be accepted as the saturation value.

PARIS.

Astronomical Society, June 6.—M. Flammarion, President, in the chair.—Various drawings and observations were sent by MM. Petit, Rengel, and G. Vallet.—M. Flammarion read a paper on the solar eclipses of the 19th century, shewing strong discrepancies between M. Oppolzer's charts and the results of observation. Replying to M. Oppert, M. Flammarion said he should not advise historians to base their investigations on those charts.—M. M. Cornillon sent drawings of a large sunspot from May 11 to 23. M. Schmoll said that this spot was just on the limits of visibility to the naked eye from May 16 to 18.—M. Gaudibert sent a drawing of the lunar crater Flammarion. A fine rill traverses this crater, and extends to Réaumur after being interrupted by some hills.—M. Schmoll related an observation of the lunar crescent on May 12, the moon being 42½ hours old. Its breadth was from 30″ to 35″.—M. Trouvelot presented to the Society a series of celestial photographs offered by Prof. Pickering, of Harvard College. The photograph of the Pleiades is specially interesting, and shows the straight trails of nebulous matter which form such a striking feature in the last negatives obtained by MM. Henry.—Thanks were returned to Prof. Pickering, who was unanimously named honorary member of the Society on the proposition of M. Trouvelot and Colonel Laussedat.—Colonel Laussedat explained his method of computing solar eclipses graphically, which is two or three times more rapid than the usual numerical calculation.

AMSTERDAM.

Royal Academy of Sciences, June 30.—M. Beyerinck stated the results he has obtained from experiments on hybridism or crossings with common barley (*Hordeum vulgare, H*) *hexastichon*, *H. distichon*, *H. Zeocriton*, and *H. trifurcatum.* made by him since 1884 on a large scale, and illustrated his subject with specimens, some dried and others preserved in spirits. He described the precautions to be taken in such crossing experiments, and deduced the following conclusions:—(1) All the above-mentioned sorts of barley may be crossed with facility, indiscriminately. (2) The hybrids thus obtained are very perfectly self-fertile; those produced from *H. vulgare* (fem.) and *H. distichon* (m.), and those from *H. vulgare* (fem.) and *H. Zeocriton* (m.) even cleistogamous. (3) The hybrids of the first generation partake in general of a middle shape between the two parents. An exception to this rule was made by those of *H. nudum* (fem.) and *H. trifurcatum* (m.), a great part of which proved to belong to the not expected common intermediate form between *H. vulgare* and *H. distichon.* A few specimens belonged to the expected *cornutum* form. (4) The seedlings from hybrids obtained by self-fertilization are very various. The speaker obtained, besides a few already known ones, some quite new varieties. It was remarkable that the third generation of a cross between *H. vulgare* (fem.) and *H. Zeocriton* (m.) produced *H. hexastichon.* (5) In the present summer, a cross effected in 1884 between *H. distichon* (fem.) and *H. trifurcatum* (m.) produced a form almost completely without awns.—M. Fürbringer imparted the results of a research made by M. J. F. van Bemmelen into the origin of the fore-limbs and of the lingual muscles in reptiles.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Electric Lighting; Its Present Position and Future Prospects: Hammond and Co. (Whitehead, Morris, and Lowe).—A System for the Construction of Crystal Models on the Type of an Ordinary Plait: John Gorham (Spon).—An Introduction to the Science and Practice of Photography: Chapman Jones (Iliffe and Sons).—Religion and Science: W. Fitzgerald (Hodges, Figgis, and Co.).—A Practical Decimal System for Great Britain and her Colonies: R. T. Rohde (E. Wilson).—The Rothamsted Experiments on the Growth of Wheat, Barley, and the Mixed Herbage of Grass Land: Prof. W. Fream (Horace Cox).—Rock-Forming Minerals: Frank Rutley (T. Murby).—Smithsonian Report, 1885, Part 2 (Washington, U.S.)—The Glasgow and West of Scotland Technical College Calendar, 1888.

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